

CARBON MONOXIDE:
A MODEL ENVIRONMENTAL PUBLIC HEALTH INDICATOR

PREPARED BY
THE NATIONAL WORKGROUP ON
CARBON MONOXIDE SURVEILLANCE

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CARBON MONOXIDE AS AN ENVIRONMENTAL PUBLIC HEALTH HAZARD AND OUTCOME

Carbon monoxide (CO) is a colorless, odorless, toxic gas that results from the incomplete combustion of fossil fuels such as natural or liquefied petroleum gas, oil, wood, and coal. It is one of the oldest documented poisons. The resulting toxic effects of CO exposure are nonspecific. For lower-level exposures (below 100 ppm) symptoms may include headache, dizziness, and nausea; higher levels of exposure (above 150-200 ppm) may result in disorientation, unconsciousness, and death. Because of the non-specific nature of the symptoms, they may be easily attributed to other causes, such as a viral illness.

Mortality and morbidity from acute, unintentional, non-fire-related CO poisoning is a substantial public health problem in the United Statesⁱ, where CO intoxication is the most common cause of unintentional poisoning.¹ An estimated 15,200 persons seek medical attention annually in an emergency department (ED) or miss at least 1 day of work due to exposure to CO.² However, because the toxic effects of CO exposure are nonspecific and easily misdiagnosed, this estimate does not account for the full burden of illness. The estimate also does not account for those directly admitted to a hospital, those presenting to other types of outpatient clinics, calling poison control centers, or who do not seek care.

The reported incidence of CO poisoning has remained stable from 1992 to 2002,³ while mortality rates have declined, from 20.1 to 8.8 deaths per million people, from 1968 to 1998. This decline has been largely attributed to the reduction in CO emissions from automobiles, and as well as other heightened public health prevention efforts and improved treatment.⁴

CO poisoning occurs as the result of routine domestic, occupational, and recreational activities. It is also increasingly recognized as a public health concern in the wake of large-scale disasters such as those caused by hurricanes,^{5,6} floods,⁷ and ice storms.^{8,9} Yet it is almost entirely preventable by the correct installation, maintenance, and operation of devices that may emit CO, combined with the appropriate use of CO detectors.

ⁱ Intentional and fire-related CO poisoning have other public health pathways for surveillance, prevention, and control are therefore not addressed in this paper.

THE CASE FOR PUBLIC HEALTH SURVEILLANCE OF CARBON MONOXIDE POISONING

The need for nationwide surveillance is recognized in the Healthy People 2010 goal for the United States of *“increasing the number of Territories, Tribes, and States, and the District of Columbia that monitor carbon monoxide poisoning from 7 to 51.”*¹⁰ CO poisoning is already reportable in 15 states.¹¹

Public health surveillance data systems are established and maintained for three purposes: immediate public health action (“case-based” surveillance, where individual case reports trigger investigations and preventive interventions); planning and evaluation (“rate-based” surveillance, where case reports are aggregated and normalized across populations and/or time, and used to estimate magnitude and monitor trends, identify high-risk groups and modifiable factors, and assess effectiveness of disease control and prevention); and, generating hypothesis for research. Any single surveillance system may have one or more of these purposes; depending upon the design of a specific data system,¹² CO surveillance may address all of these purposes.

Public health surveillance is conducted for many health conditions for which there are recognized, evidence-based primary or secondary prevention strategies; however, this is not, by and large, the case for CO poisoning. There are basic gaps in our knowledge of the epidemiology and outcomes of CO poisoning, including the long-term sequelae, prevention and risk behaviors. An ongoing, national surveillance system would lay the basis to address these gaps as well as guide the development and evaluation of local, state, and national prevention programs. Goals of a national system may include:

1. *To plan for rapid response:* CO poisoning surveillance has a critical function for rapid response; excess cases of CO poisoning related to large-scale power outages and the ability to identify that cases are occurring, as well as the sources of exposure, are critical.
2. *To measure and track the burden of CO poisoning over time:* Numerous one-time summaries of the epidemiology of CO poisoning at the state^{13,14} and national,^{1,2,3,4,15} level have been published, but none of ongoing tracking.
3. *To understand the relative contribution of exposure sources:* While there is a clear relationship between environmental exposure to CO and adverse health outcomes, the literature about the contribution of various exposure sources (motor vehicle, furnaces,

gas-powered appliances) and the settings in which exposures occur (occupational, residential or recreational) is limited. There are multiple reports of one-time and novel exposures,^{16,17} and at least one in-depth report characterizing non-vehicular exposures resulting in unintentional mortality in a western state.¹⁸ Better characterization of exposure sources and settings is vital for prevention and intervention. Systematically characterizing exposure sources may also potentially identify novel exposure sources. A nationwide system is needed because exposure sources may vary regionally. Additionally, exposure sources for CO poisoning that occur as part of routine domestic, occupational and recreational activities likely vary compared to those occurring in the wake of a natural disaster.

4. *To evaluate interventions:* Intervention strategies to reduce the occurrence of CO poisoning have been launched by public health agencies both in the wake of large-scale power outages, and, in some northern states before winter to reduce the expected seasonal increase in cases. A surveillance system would provide data to evaluate, and revise, these interventions.
5. *To promote and facilitate related research:* By identifying cases, public health surveillance could lay the basis for research needed to address many of the unresolved public health issues about CO poisoning. For example, a significant proportion of survivors of acute CO poisoning may have persistent, serious neurological injury,¹ however little is known about the prevalence, or associated risk factors. Additionally, excess cardiovascular disease (CVD)-related mortality has been associated with chronic moderate and high levels of exposures to CO.¹⁹ The effects on other health outcomes, and of chronic low-level exposures, particularly in regards to occupational settings, are less well understood. There is a growing body of literature that shows an ecological association between increased levels of ambient air CO with adverse CVD,^{20,21} stroke,²² and birth outcomes,^{23,24} which supports the need to investigate long-term sequelae of chronic low-dose exposures. A surveillance system might also provide the basis to establish exposure registries that may support research into these important questions.
6. *To characterize related hazards:* CO hazards may be an indicator for broader environmental hazards, including housing disrepair, poor ventilation, and other events that may lead to other adverse health outcomes.

CARBON MONOXIDE POISONING AS AN IDEAL CANDIDATE FOR EARLY IMPLEMENTATION IN A NATIONAL EPHT NETWORK

The goals of the national Environmental Public Health Tracking (EPHT) Program are to: 1) Build a sustainable national EPHT Network (EPHTN); 2) Enhance the capacity of the environmental public health workforce and infrastructure; 3) Disseminate information to guide policy; 4) Advance environmental public health science and research; and, 5) Foster collaboration among health and environmental programs.²⁵ The following section of this document will address how CO poisoning is an ideal candidate for inclusion in the EPHT Program priorities in the context of each of these goals.

1. Build a sustainable national EPHT Network

A key component of the national EPHT program is the initiative to build a national EPHTN. The EPHTN will be a sustainable, standards based, interactive network that will integrate scientifically valid data on environmental hazards, exposures and related health outcomes. The vision for the network is interactive, providing the capacity for linking health effects, exposure and hazard information with the ultimate goal of reducing morbidity and mortality related to environmental contaminants.

CO poisoning is an ideal candidate for early incorporation into a national EPHT network for several reasons:

- a. CO is a ubiquitous hazard; there are potential sources of CO exposure in most homes and workplaces in the United States, including furnaces, motor vehicles, generators, gas heaters and other small-engine powered appliances such as lawn mowers, power washers and recreational vehicles including boats, aircraft, 4-wheelers and snowmobiles.
- b. Most states have multiple data sources for estimating the burden of illness due to acute poisonings from CO exposure. Data sources currently available include:
 - Hospitalization data, available in 90% of states;²⁶
 - ED data, available in 50% of states;²⁶
 - BRFSS data, available in all state and territories and,

- Poison control calls data that could be readily adapted for incorporation into a national network.
- c. Many of these data sources are already under consideration for incorporating into a national network. Other data sources to be investigated and standardized include: hyperbaric chamber utilization information, laboratory test results for elevated carboxyhemoglobin using electronic lab reporting infrastructure established by PHIN-NEDSS, Medical Examiner/Coroner records, media reports, Emergency Medical Services (EMS) and fire fighter response and inspection records.
 - d. Because exposures are ubiquitous and data sources are similar across jurisdictions, lessons learned in one jurisdiction are easily applied to others. Likewise, there are likely regional differences in burden or exposure setting and/or source that need to be investigated. This can only be accomplished with nationally compiled data.
 - e. There is already a national workgroup that is working to revise the national case definition for surveillance. This workgroup could be a forum for developing other model standards for reporting data into the EPHTN including: methods of reporting (e.g. data items to be reported, timing of reporting) and guidelines for case investigations in routine and disaster-related cases that would include the relative contribution of different exposures, the identification of novel exposure sources, and the identification of undiagnosed cases.
 - f. To develop a model for real-time reporting. Because of the acute relationship between exposure and symptom onset, CO poisoning may serve as a model for real-time disease reporting and response.

Additionally, CO poisoning is an excellent model for exploring the potential capacity for linking health effects, exposure and hazard information, with potential for linkage projects to explore the adverse effects of both indoor and outdoor air quality. Some potential linkage projects include:

- The volume of generator sales and the frequency of CO poisoning (the price of generators is decreasing and their ownership/use is being promoted as part of emergency preparedness by FEMA).
- Evaluating the effectiveness of marketing strategies for prevention by linking outcome data with either marketing data or BRFSS data (examples of marketing

strategies include the co-sale of outdoor extension cords (a promotion currently done by one or more of the big home-improvement chains) to promote correct use of generators; or, the co-sale/promotion of CO detectors with generators).

- Assess the contribution of weather-related factors (alternative heating sources) by linking with power utility data.
- Linkage of CO poisoning health outcome data with housing data to understand the role of housing age and condition (e.g. is CO poisoning more likely in older homes or homes in poor condition?).

2. Enhance the capacity of the environmental public health workforce and infrastructure

The lack of a coherent system to track CO poisoning nationwide has resulted in a corresponding gap in local, state and national capacity to conduct public health practice activities for the prevention of CO poisoning. Developing a surveillance system for CO poisoning would enhance capacity in the basic public health function of building and maintaining a surveillance system; increase staff knowledge about the occurrence, sources and health outcome of CO poisoning; support related ongoing public health efforts such as the BRFSS; and potentially increase technical capacity to develop an integrated environmental public health surveillance system.

Additionally, there is a growing recognition of the need to develop systems to begin CO surveillance in the wake of large-scale disasters, where the use of alternative fuel and cooking sources can lead to excess CO-related morbidity and mortality. Recent experience with the post-hurricane Katrina and Rita public health response demonstrated the need to use novel data sources and data collection techniques.⁵ Protocols need to be developed for putting these systems in place in the absence of a pre-existing system, or quickly and seamlessly transitioning from an existing system for routine surveillance to the disaster-related surveillance system. Additionally, a national system would provide a platform for planning and coordination with other public health response programs.

3. Disseminate information to guide policy

A surveillance system includes the dissemination of information and the use of that information to guide public health practice and policy. It has been estimated that CO detectors could prevent half of all deaths attributable to CO poisoning and a much higher proportion where alcohol consumption was not a factor.²⁷ A number of jurisdictions have mandated the placement of CO detectors; some have conducted one-time evaluations of these laws. However, surveillance data are needed to monitor and to evaluate the ongoing effectiveness of the legislation and guide interventions. Examples of legislation mandating CO detectors in residential settings and some related evaluations include:

- **Alaska:** Beginning January 2005, all homeowners and landlords in Alaska who use gas, oil, wood, coal or other CO producing heating fuel are required to install carbon monoxide detectors in their homes (H.B. 351, 23rd Alaska Legislature, Second Session).
- **Massachusetts:** An act (Senate no. 2152) was passed July 13th 2005, requiring that every dwelling, building or structure occupied in whole or in part for residential purposes and that (1) contain fossil fuel burning equipment or (2) incorporate closed parking within its structure, be equipped by the owner with approved carbon monoxide alarms.
- **New York City:** A law (Local Law 7 of 2004) was passed requiring building owners to install at least one approved carbon monoxide detector in each dwelling unit, within 15 feet of the entrance to any bedroom. The law also requires detectors in hotels, schools, libraries, hospitals, and nursing homes. Exemptions are provided for buildings that do not have and are not located adjacent to buildings that have fossil fuel burning furnaces/boilers/water heaters, fireplaces, enclosed parking spaces, and commercial (non-domestic use) ranges. In addition, the NYC Health Code was updated November 19, 2004 to explicitly define carbon monoxide poisoning (carboxyhemoglobin above 10%) as an immediately reportable condition. The code requires the NYC Poison Control Center (PCC) to rapidly refer case information to the NYC Fire Department for investigation to identify and prevent possible additional cases of CO poisoning at the site of a sentinel event. The NYC EPHT Program is currently conducting an evaluation of these two policy changes.

- **North Carolina, Mecklenburg County** (*Includes the city of Charlotte*): A public health ordinance requiring a CO detector in the majority of residences was adopted in 2000. An evaluation of the effectiveness of the ordinance was conducted following an ice storm, which caused 78.9% of houses in the county to be without electricity. There were 124 cases of symptomatic CO poisoning reported in 9 days; the investigation determined that 96% of the severe cases of CO poisoning occurred in homes without a functioning CO detector. As a result of the evaluation, the ordinance was amended to require an alarm in every residence and that each alarm has a battery back-up.²⁸
- **Vermont**: A law (Title 9: Commerce and Trade *Chapter 77*) requiring the installation of carbon monoxide detectors in all buildings in which people sleep was passed in May 2005. The law was structured in phases: 1) Immediately required every single-family home being sold or transferred in Vermont to contain at least one working carbon monoxide detector; 2) As of July 1, 2005, all new construction would require CO detectors; 3) As of October 1, 2005 all other buildings in which people sleep, including apartments, hotels and multi-family homes, were mandated to have working CO detectors.

4. *Advance environmental public health science and research*

There are a number of public health science and research topics related to CO poisoning that could be investigated by EPHT grantees once CO poisoning is recognized as national priority. A significant proportion of CO poisoning survivors may have persistent, serious neurological injury including depression, anxiety and gait/movement disorders,¹ however little is known about the prevalence or associated risk factors. Because of the acute nature of the exposure and illness onset, CO poisoning may lend itself well to establishment of follow-up registries that facilitate research to address these, and other issues.

5. *Foster collaboration among health and environmental programs*

The topic of CO poisoning has historically brought together a diverse group of stakeholders. Many of these are traditional public health partners including public and not-for-profit injury prevention programs, ED clinicians, first-responders such as EMS and fire fighters, the Consumer Product Safety Commission, academicians, poison control centers and citizen interest groups.

CARBON MONOXIDE POISONING AS AN IDEAL ENVIRONMENTAL PUBLIC HEALTH INDICATOR

Establishing surveillance for CO poisoning is but one element of environmental public health surveillance. Environmental public health surveillance goes beyond surveillance of health outcomes; these systems ideally capture, characterize and disseminate information on a population's status in regards to the hazard, exposure, health effects and interventions (Figure 1).

The Council of State and Territorial Epidemiologists (CSTE) “supports and encourages the development and use of Environmental Public Health Indicators, developed in collaboration with the Center for Disease Control and Prevention's (CDC) National Center for Environmental Health (NCEH) for building state-based programs for environmental hazards, exposures, and adverse health outcomes.”²⁹ By the CDC definition, “An environmental public health indicator (EPHI) provides information about a populations' health status with respect to environmental factors. It can be used to assess health or a factor associated with health (i.e. risk factor, intervention) in a specified population through direct or indirect measures.”³⁰

Data sources already exist to track hazard, exposure, health outcome, and intervention EPHIs for CO. Those for tracking health outcome EPHIs are discussed at length above. For hazard surveillance of CO, readily available data sources include CO emissions data that are available from the U.S. Environmental Protection Agency (EPA) National Emission Inventory database and/or using concentrations from air monitoring station data that are available from the EPA Air Quality System database. However, only a few areas in the United States do not attain EPA ambient air standards for CO levels.³¹ Two other sources of potential, yet largely untapped, data are utility companies and fire departments. Utility companies are required, in most states, to take and investigate calls about potential gas leaks from appliances, as well as other complaints, and in that context do environmental testing for carbon monoxide. Fire departments respond to similar calls as well as to carbon monoxide detector alarms. While these data may represent a rich source of hazard information, there are some barriers to their use including that the data are typically not in an electronic format and, especially in the cases of utility companies, that these are not traditional public health partners.

Figure 1: Definitions for the components of an environmental public health surveillance system.ⁱ

<p><u>Hazard surveillance:</u></p> <p>Tracking and assessment of the occurrence and distribution of levels of environmental hazards (e.g. chemical agents, biochemical stressors) that are responsible, or have the potential for being responsible for, disease and/or injury.</p>
<p><u>Exposure surveillance:</u></p> <p>The monitoring of individual members of a population for the presence of an environmental agent, or combination of agents, or for the direct result of exposure, such as subliminal effects.</p>
<p><u>Environmental health outcomes surveillance:</u></p> <p>The ongoing systematic collation, analysis, interpretation and dissemination of data related to specific health outcomes that are associated with known or suspected environmental hazards, closely integrated with the dissemination of these data to those responsible for prevention and control.</p>
<p><u>Intervention:</u></p> <p>The monitoring of prevention or control programs and/or official policies that minimize or prevent agents from becoming environmental hazards, exposure to hazards, or health-related events.</p>
<p>ⁱ From: Thacker SB, Stroup DF, Parrish RG, Anderson HA. Surveillance in environmental public health: issues, systems, and sources. <i>Am J Public Health.</i> 1996 May;86(5):633-8</p>

An EPHI for CO exposure could be developed and tracked using laboratory test results for elevated carboxyhemoglobin levels, using the electronic laboratory reporting infrastructure already established for blood lead tests results.

Likewise, an intervention EPHI could be based on questions asked in the BRFSS. In 2004, six states, Alaska, Delaware, Florida, Maine, Mississippi, and Montana asked their BRFSS respondents the following question: “A carbon monoxide or CO detector checks the level of carbon monoxide in your home. It is not a smoke detector. Do you have a carbon monoxide detector in your home?” The results ranged from 19.6% in Florida to 53.0% in Alaska.ⁱⁱ Additionally, two states, Maine (2004) and Washington (2006) have used questions to assess generator ownership, use, and placement (Appendix 1). This mechanism can be used to assess risk and prevention behavior for both in disaster and non-disaster related cases of CO poisoning. (BRFSS data was used by Florida to assess the public health impact of four hurricanes.)³²

ⁱⁱ Prevalence estimates determined based on household weights.

Each of these EPHI have the characteristics that CDC defines as “Attributes of an Ideal EPHI”, including being: measurable; trackable over time; based on a demonstrated link between environments and health; useful and understood by diverse populations; informative to the public and to responsible agencies; tied to public health objectives; and incorporated in clear case definitions. CO and CO poisoning provides an opportunity to develop and track a full suite of EPHIs that fulfill all of these attributes.

COORDINATION OF A NATIONWIDE CO SURVEILLANCE SYSTEM

CDC has recently designated a home for CO surveillance, in the NCEH, Division of Environmental Hazards, and Health Effects (DEHHE). Recognizing that CO poisoning crosses many public health jurisdictions other than environmental health, including injury, occupational and emergency response, DEHHE has begun coordinating CO surveillance efforts with many partners. There is also ongoing coordination between the programs within DEHHE that work most closely with CO surveillance, the Air Pollution and Respiratory Health and Environmental Public Health Tracking Programs. This coordinated response, with other public health agencies and partners both within and external to CDC, is a vital step to establishing a nationwide public health surveillance system for CO poisoning.

CONCLUSION

The challenges to establishing a nationwide system for public health surveillance are formidable and include the need to standardize data collection, analysis, and dissemination methodologies and the need for resources at the national, state and local level. CO surveillance is technically feasible; the data sources and the technical expertise to gather, analyze, and disseminate them exist in the current public health infrastructure. The leading challenges are the need for the recognition of CO poisoning as a significant public health issue by public health practitioners, clinicians, and policy makers, and the subsequent identification and dedication of the necessary resources.

Appendix 1: BRFSS questions that have been used for surveillance of risk factors and prevention behaviors related to carbon monoxide exposure.ⁱ

The next set of questions is about using gas-powered generators.

1. Has a gas-powered generator ever been used to provide electric power to your home during a power outage?

- 1 Yes
- 2 No **[Go to question 6]**
- 7 Don't Know / Not Sure **[Go to question 6]**
- 9 Refused

2. Was this generator used to provide power for your home during a power outage in the past year?

- 1 Yes
- 2 No **[Go to question 4]**
- 7 Don't Know **[Go to question 4]**
- 9 Refused **[Go to question 4]**

3. How many times in the past year was -a generator used to provide power to your home because of a power outage?

- ___ ___ Number of times **[87 = 87 or more]**
- 88 None
- 98 Don't know/Not sure
- 99 Refused

4. Where was the generator usually placed when it was running?

Please Read

- 1 Outdoors
- 2 Inside an attached garage, shed or enclosed porch **[Go to question 6]**
- 3 In a detached garage, shed or out-building **[Go to question 6]**
- 4 In another location, (**Specify** _____) **[Go to question 6]**

Do Not Read

- 7 Don't know / Not sure **[Go to question 6]**
- 9 Refused **[Go to question 6]**

ⁱ Developed by the Maine Environmental and Occupational Health Unit; Maine CDC (formally Maine Bureau of Health; Maine Department of Health and Human Services

5. If it was raining or snowing outside, when the generator was running, where was the generator usually placed?

Please Read

- 1 Outdoors
- 2 Inside an attached garage, shed or enclosed porch
- 3 In a detached garage, shed or out-building
- 4 In another location, (**Specify_____**)

Do Not Read

- 7 Don't know / Not sure
- 9 Refused

6. Do you or anyone in your home own a gas-powered generator?

- 1 Yes
- 2 No
- 7 Don't know
- 9 Refused

7. A carbon monoxide or CO detector checks the level of carbon monoxide in your home. It is not a smoke detector. Do you have a carbon monoxide detector in your home?ⁱⁱ

- 1 Yes
- 2 No **[Go to next section]**
- 7 Don't Know **[Go to next section]**
- 9 Refused **[Go to next section]**

8. Is your carbon monoxide detector battery powered or have a battery for back-up power?

- 1 Yes
- 2 No
- 7 Don't Know
- 9 Refused

9. When was the last time you checked the batteries? Was it....

Read List Only If Necessary

- 1 Within the past year
- Or**
- 2 More than a year
 - 7 Don't know / Not sure
 - 9 Refused

ⁱⁱ Questions made available by CDC, as part of the "Indoor Air Quality" optional module:

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1. Ernst A, Zibrak JD. Carbon monoxide poisoning. *N Engl J Med*. 1998 Nov 26;339(22):1603-8.
 2. CDC. Unintentional non-fire-related carbon monoxide exposures – United States, 2001-2002 *MMWR*: 2005; 54(02);36-39
 3. Hampson, NB. Trends in the incidence of carbon monoxide poisoning in the United States. *Am J Emerg. Med*. 2005; 23: 838-841
 4. Mott JA, Wolfe MI, Alverson CJ, Macdonald SC, Bailey CR, Ball LB, Moorman JE, Somers JH, Mannino DM, Redd SC. National vehicle emissions policies and practices and declining US carbon monoxide-related mortality. *JAMA*. 2002 Aug 28; 288(8):988-95
 5. CDC. Carbon monoxide poisoning after hurricane Katrina – Alabama, Louisiana, and Mississippi, August—September 2005. *MMWR*. 2005;54(39):996-1000
 6. CDC. Carbon monoxide poisonings after two major hurricanes – Alabama and Texas, August—October 2005. *MMWR* .2006;55(9):236-243
 7. CDC. Public health consequences of a flood disaster. *MMWR*. 1993;42(34):653-656
 8. Houck PM, Hampson NB. Epidemic carbon monoxide poisoning following a winter storm. *J. Emerg Med*. 1997 Jul-Aug;15(4):469-473
 9. Daley RW, Smith AE, Paz-Argandona E et. al. An outbreak of carbon monoxide poisoning after a major ice storm in Maine. *J. Emergency Med*. 2000;18(1):87-93
 10. U.S. Department of Health and Human Services. Healthy People 2010: Understanding and Improving Health. 2nd ed. Washington, DC: U.S. Government Printing Office, November 2000. available at: <http://www.usmc-mccs.org/healthfitness/HealthyPeople2010/tableofcontents.htm>
 - 11 Council of State and Territorial Epidemiologists. National Notifiable Disease Surveillance System; Reporting patterns of non-notifiable diseases and conditions; 2005
 12. Seligman PJ, Frazier. Surveillance: The sentinel Health Event Approach. *In*: Halperin W, Baker EL, Monson RR, eds. *Public Health Surveillance*. New York, NY: Van Nostrand Reinhold, 1992

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13. CDC. Unintentional carbon monoxide poisonings in residential settings – Connecticut, November 1993-March 1994. MMWR. 1995. 44(41): 765-767
 14. Girman JR, Chang YL, Hayward SB, Liu KS.. Causes of unintentional deaths from carbon monoxide poisonings in California. West J Med. 1998 Mar;168(3):158-65
 15. Cobb N, Etzel RA. Unintentional carbon monoxide-related deaths in the United States 1979 through 1988. JAMA 1991; 266:659-63
 16. CDC. Outdoor carbon monoxide poisoning attributed to tractor exhaust. MMWR 1997; Vol. 46(51):1224-1227
 17. Carbon monoxide poisoning resulting from open exposures to operating motorboats – Lake Havasu City, Arizona. MMWR, 2004; Vol. 53(15):314-318
 18. Liu KS, Paz MK, Flessel P, Waldman J, Girman J. Unintentional carbon monoxide deaths in California from residential and other nonvehicular sources. Arch Environ Health. 2000 Nov-Dec; 55(6):375-81
 19. Henry CR, Satran D, Lindgren B, Adkinson C, Nicholson CI, Henry TD. Myocardial injury and long-term mortality following moderate to severe carbon monoxide poisoning. JAMA. 2006 Jan 25;295(4):398-402
 20. Chang CC, Tsai SS, Ho SC, Yang CY. Air pollution and hospital admissions for cardiovascular disease in Taipei, Taiwan. Environ Res. 2005 May; 98(1):114-9
 21. Yang CY, Chen YS, Yang CH, Ho SC. Relationship between ambient air pollution and hospital admissions for cardiovascular diseases in Kaohsiung, Taiwan. J Toxicol Environ Health A. 2004 Mar 26;67(6):483-93
 22. Tsai SS, Goggins WB, Chiu HF, Yang CY. Evidence for an association between air pollution and daily stroke admissions in Kaohsiung, Taiwan. Stroke. 2003 Nov;34(11):2612-6. Epub 2003 Oct 9
 23. Salam MT, Millstein J, Li YF, Lurmann FW, Margolis HG, Gilliland FD. Birth outcomes and prenatal exposure to ozone, carbon monoxide, and particulate matter: results from the Children's Health Study. Environ Health Perspect. 2005 Nov;113(11):1638-44
 24. Wilhelm M, Ritz B. Local variations in CO and particulate air pollution and adverse birth outcomes in Los Angeles County, California, USA. Environ Health Perspect. 2005 Sep;113(9):1212-21

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25. CDC. CDC's strategy for the National Environmental Public Health Tracking Program; Fiscal Years 2005 – 2010. Department of Health and Human Services, 2005
 26. Abellera, J, Annett J, Conn, JM, Kohn, M. How states are collecting and using cause of injury data: 2004 update to the 1997 report. Council of State and Territorial Epidemiologists; Data Committee Injury Control and Emergency Health Services Section; American public Health Association; State and Territorial Injury Prevention Directors Association. March 2005
 27. Yoon SS, Macdonald SC, Parrish RG. Deaths from unintentional carbon monoxide poisoning and potential for prevention with carbon monoxide detectors. JAMA. 1998 Mar 4;279(9):685-687
 28. CDC. Use of carbon monoxide alarms to prevent poisonings during a power outage – North Carolina, December 2002. MMWR. 2002; Vol 53(9) 189-192
 29. Available at: **<http://www.cste.org/ps/2001/2001-env-02.htm>**.
 30. CDC online at: **<http://www.cdc.gov/nceh/indicators/introduction.htm>**
 31. US Environmental Protection Agency. More Details on Carbon Monoxide - Based on Data Through 2002, available at: <http://www.epa.gov/airtrends/carbon2.html>
 32. CDC. Epidemiologic assessment of the impact of four hurricanes – Florida, 2004. MMWR. 2005; 54(28);693-697